Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____
I declare this is my own work.

A-level
ENVIRONMENTAL SCIENCE

Paper 1

Time allowed: 3 hours

Materials
For this paper you may use:
- a calculator.

Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions 1 to 10 and **one** essay from question 11.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 120.
- All questions should be answered in continuous prose.
- You will be assessed on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
TOTAL	

Do not write outside the box

Answer **all** questions in the spaces provided.

0 1 **Table 1** shows some treatment processes that are used to remove specific contaminants from water.

Complete **Table 1** by adding **one** or **more** ticks to each row to identify which treatment processes are used to remove each specific contaminant.

The first row has been completed for you.

[5 marks]

Table 1

Contaminant	**Treatment process**					
	Activated carbon filtration	Phyto-remediation	Reverse osmosis	Screening	Sedimentation	UV light
Salt			✓			
Heavy metals						
Litter						
Organic pollutants						
Pathogens						
Suspended solids						

5

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0 2 The Rowland-Molina hypothesis explains how the properties of chlorofluorocarbons (CFCs) may cause ozone depletion in the stratosphere.

0 2 . 1 Describe **two** chemical properties of CFCs on which the Rowland-Molina hypothesis is based.

[2 marks]

1 _____

_____

2 _____

_____

Question 2 continues on the next page

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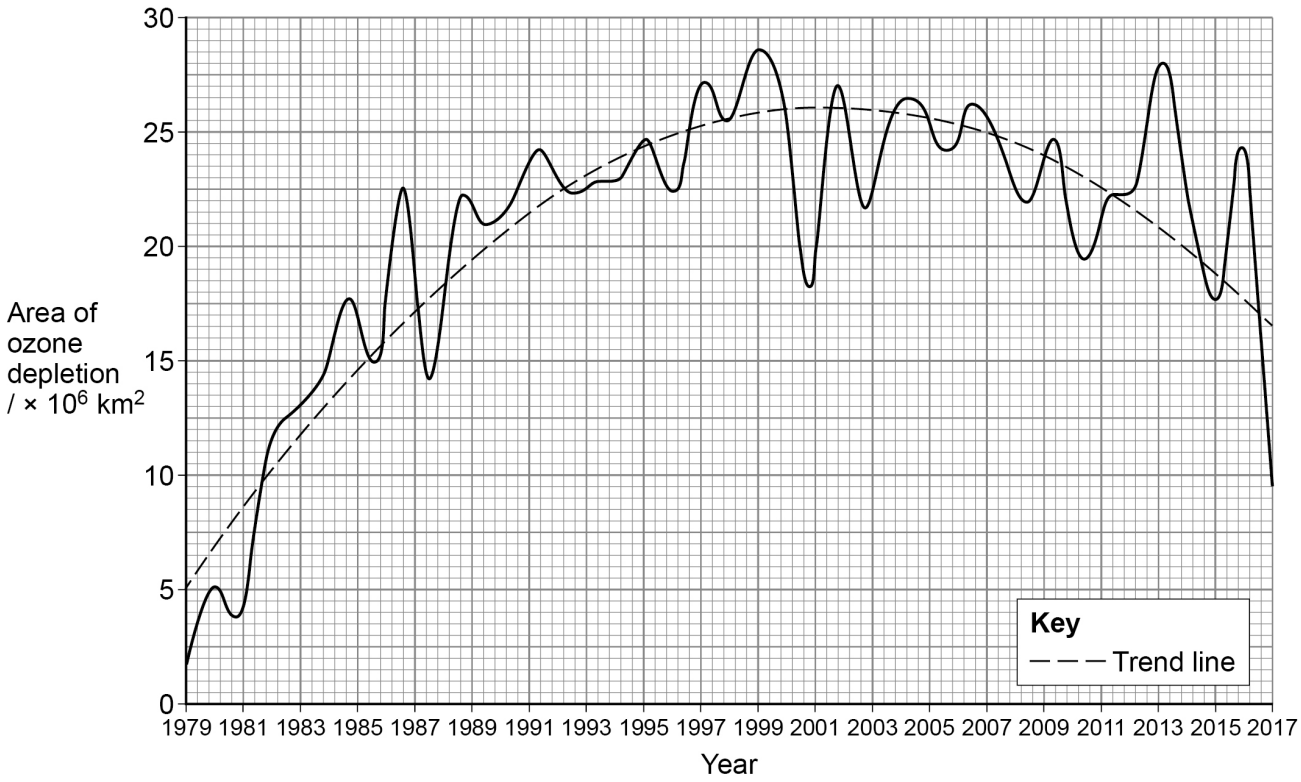
Figure 1 shows changes in the area of ozone depletion in the stratosphere from 1979 to 2017 over the Southern Hemisphere.

Figure 1



0 2 . 2 Use the trend line in **Figure 1** to calculate the mean annual rate of decrease in the area of ozone depletion over the Southern Hemisphere from 2003 to 2017.

Give your answer to **two** significant figures.

Show your working.

[2 marks]

_____ $km^2\ yr^{-1}$

Do not write outside the box

0 2 . 3 Outline how the Montreal Protocol (1987) has contributed to an increase in the concentration of ozone in the stratosphere since 2001.

[4 marks]

Extra space

0 2 . 4 Ozone depletion in the stratosphere affects living organisms.

Explain **one** possible effect of ozone depletion on living organisms.

[2 marks]

10

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0 3 Acidic pollutant gases in the atmosphere contribute to the formation of acid rain.

0 3 . 1 Explain **one** way in which acid rain may **indirectly** harm plants.

[2 marks]

Acid rain may affect the germination of crop seeds.

Students investigated the impact of acidic water on the germination of radish seeds.

They:
- used solutions pH 4, pH 5, pH 6 and pH 7
- used 100 radish seeds for each pH solution tested
- counted the number of radish seeds that germinated at each pH
- applied the Chi-squared statistical test to the data.

0 3 . 2 Suggest a suitable null hypothesis for this investigation.

[1 mark]

Do not write outside the box

Only **one** answer per question is allowed.

For each question completely fill in the circle alongside the appropriate answer.

CORRECT METHOD WRONG METHODS

If you want to change your answer you must cross out your original answer as shown.

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.

0 3 . 3 Select **one** answer below that explains why the Chi-squared statistical test is the appropriate test to use to assess the significance of the results from this investigation.

Shade **one** box only.

[1 mark]

A The data are counted in various categories and the students are investigating whether there are differences between means.

B The data are counted in various categories and the students are investigating whether there is a difference between observed and expected results.

C The data are measured and the students are investigating whether there is a difference between observed and expected results.

D The data are measured in various categories and the students are investigating whether there is a relationship between means.

Question 3 continues on the next page

Do not write outside the box

Figure 2 gives details of how to calculate and interpret the Chi-squared statistic.

Figure 2

where:
Σ = the sum of
O = the observed value
E = the expected value

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

df (degrees of freedom) = $k - 1$
where k = the number of categories to which the data have been allocated

Critical values for the Chi-squared (χ^2) statistical test

Degrees of freedom (df)	Level of significance (p)				
	0.05	**0.025**	**0.01**	**0.005**	**0.001**
1	3.84	5.02	6.63	7.88	10.83
2	5.99	7.38	9.21	10.60	13.81
3	7.81	9.35	11.34	12.84	16.27
4	9.49	11.14	13.28	14.86	18.47
5	11.07	12.83	15.09	16.75	20.52
6	12.59	14.45	16.81	18.55	22.46
7	14.07	16.01	18.48	20.28	24.32
8	15.51	17.53	20.09	21.96	26.13

Table 2 shows the observed and expected values for this investigation and the calculated values of $\frac{(O-E)^2}{E}$

Table 2

	pH of solution			
	pH 4	pH 5	pH 6	pH 7
Total number of germinated seeds (the observed values)	56		96	98
Theoretically expected number of germinated seeds (the expected values)	85	85	85	85
$\frac{(O-E)^2}{E}$	9.89	0.29	1.42	1.99

Do not write outside the box

0 3 . 4 Use information from **Table 2** to calculate the total number of germinated seeds observed at **pH 5**.

Write your answer in the empty box provided in **Table 2**.

[1 mark]

0 3 . 5 Use information from **Figure 2** to calculate the value of χ^2 for the data in **Table 2**.

[1 mark]

χ^2 value _____

0 3 . 6 In a similar study, the students calculated a value for χ^2 of 12.46.

Use **Figure 2** to select the level of significance that can be accepted for this critical value.

Shade **one** box only.

[1 mark]

A 0.05 ⬭

B 0.025 ⬭

C 0.01 ⬭

D 0.005 ⬭

E 0.001 ⬭

Do not write outside the box

0 3 . 7 State **three** variables that would have to be controlled to make sure the results were valid.

[3 marks]

Variable 1 _____

_____

Variable 2 _____

_____

Variable 3 _____

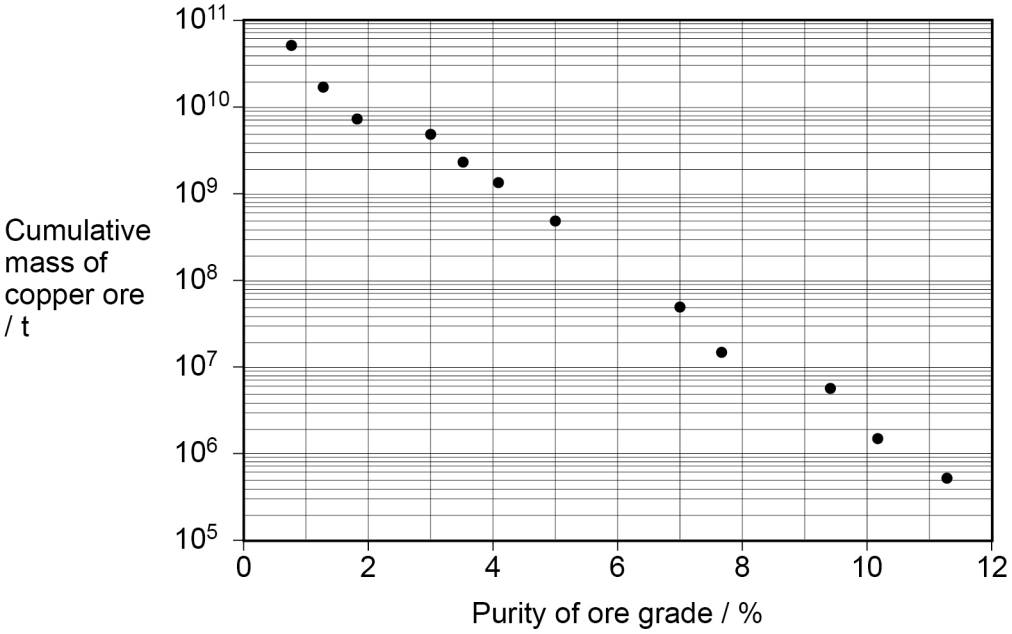
_____

10

0 4 The amount of a mineral in the Earth's crust that may be exploited depends on a number of factors.

Figure 3 shows the cumulative mass of copper ore that occurs at different purities of ore grade.

Figure 3



0 4 . 1 Explain why a logarithmic scale was used, rather than a linear scale, for the cumulative mass of copper ore in **Figure 3**.

[1 mark]

_____

_____

Do not write outside the box

0 4 . 2 Use the values in **Figure 3** to explain the effect on resource and reserves of an increase in the cut-off ore grade of copper from 3% to 5%.

[3 marks]

0 4 . 3 Explain why, other than ore purity, a mineral deposit may **not** be exploited.

[6 marks]

Extra space

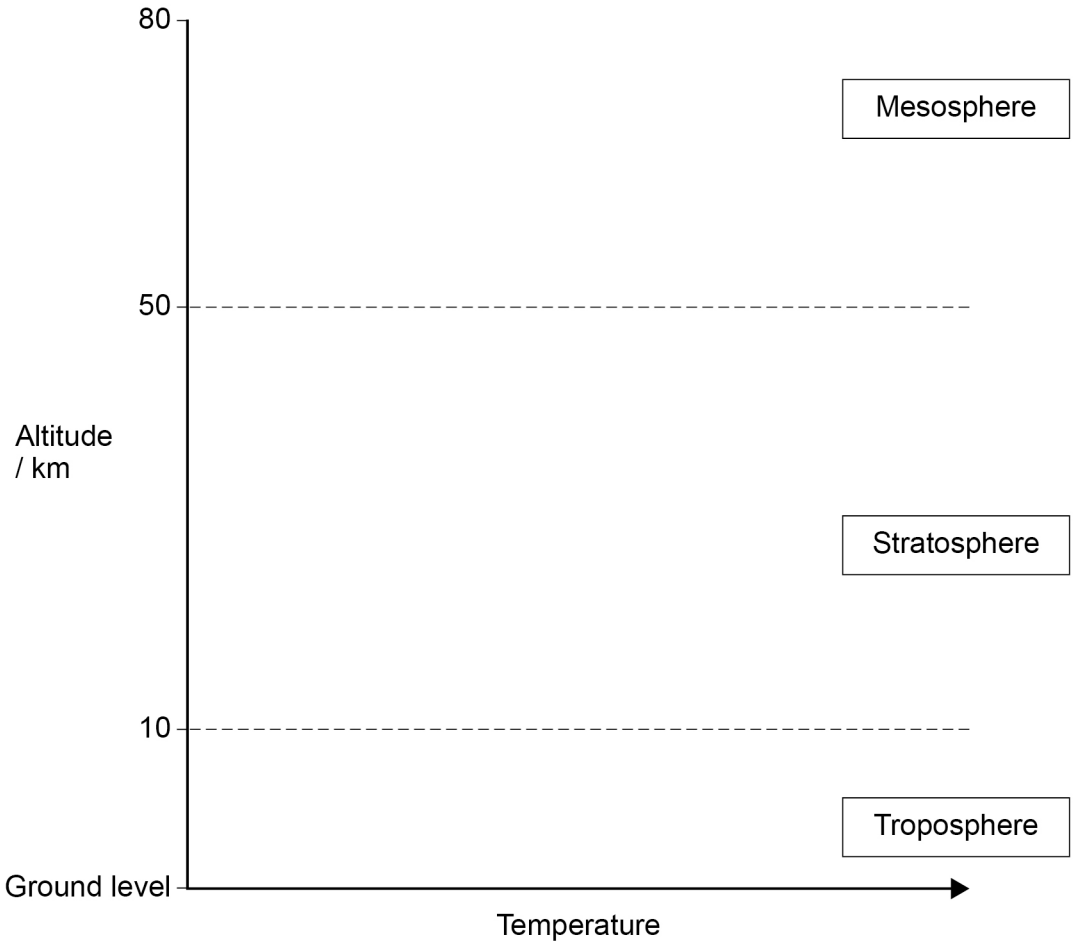
10

Turn over ►

Do not write outside the box

0 5 **Figure 4** shows the structure of the atmosphere.

Figure 4



0 5 . 1 Draw a line on **Figure 4** to show the temperature change with increasing altitude from ground level up to 80 km. Start your line at ground level.

[1 mark]

Do not write outside the box

0 5 . 2 Outline how the following layers of the atmosphere are heated by electromagnetic radiation.

[4 marks]

Stratosphere _____

_____

_____

_____

Troposphere _____

_____

_____

_____

5

Turn over for the next question

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0 6 Management of water resources in India has become an increasing challenge over the past 50 years.

India has large seasonal and regional differences in water availability.

Table 3 shows water resources and demand in India.

Table 3

	Water resources / $\times 10^9$ m^3 yr^{-1}		Water demand / $\times 10^9$ m^3 yr^{-1}		
Mean precipitation / $\times 10^9$ m^3 yr^{-1}	**Mean usable surface water**	**Mean usable groundwater**	**Water demand 2010**	**Water demand (projected) 2025**	**Water demand (projected) 2050**
4 000	690	447	710	843	1180

0 6 . 1 Suggest **two** reasons for the difference between mean precipitation and available water resources.

[2 marks]

1 _____

_____

2 _____

_____

0 6 . 2 Calculate the projected percentage increase in demand for water from 2010 to 2050.

Give your answer to **three** significant figures.

Show your working.

[2 marks]

_____ %

Do not write outside the box

0 6 . 3 Outline how a country such as India could use named methods to manage its water resources sustainably.

[6 marks]

Extra space

10

Do not write outside the box

0 7 Some agricultural practices have contributed to soil erosion.

0 7 . 1 Explain **three** ways in which named agricultural practices may increase soil erosion.

[6 marks]

1 _____

_____

_____

_____

2 _____

_____

_____

_____

3 _____

_____

_____

_____

Do not write outside the box

Stone walls mark field boundaries in many areas of the UK.

They also help reduce soil erosion by acting as windbreaks, reducing the effects of wind.

0 7 . 2 Outline a plan to investigate how wind speed changes with increasing distance from a stone wall.

[4 marks]

Extra space

10

Turn over for the next question

Do not write outside the box

0 8 In 2019, 3.9% of UK electricity was produced by solar photovoltaic cells (PV).

Table 4 shows the increase in solar PV capacity from June 2014 to June 2019.

Table 4

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0 8 . 1 Use **Table 4** to calculate the mean **annual percentage rate** of increase for solar PV capacity from June 2014 to June 2019.

Give your answer to an appropriate number of significant figures.

Show your working.

[2 marks]

_____ %

Do not write outside the box

The increase in solar PV generating capacity is largely due to additional installations, such as for domestic use and solar farms, and an increase in the efficiency of solar PV panels.

0 8 . 2 Explain **two** ways in which an improvement in the design of solar PV panels has increased the efficiency.

[4 marks]

1 _____

_____

_____

_____

2 _____

_____

_____

_____

Question 8 continues on the next page

Do not write outside the box

PS20 is a concentrating solar power plant in Spain.

It has a potential maximum output of 20 MW and an actual annual output of 48 GWh.

The capacity factor of an electricity-producing installation is defined as:

$$\text{Capacity factor} = \frac{\text{actual output}}{\text{potential maximum output}} \times 100\%$$

0 8 . 3 Use information in the text above to calculate the capacity factor of the PS20 solar power plant.

Give your answer to **two** significant figures.

Show your working.

[3 marks]

_____ %

0 8 . 4 State **one** method, other than battery storage, by which the energy generated by PS20 might be stored for use after dark.

[1 mark]

_____

_____

10

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0 9 Nitrogen compounds have increased in the atmosphere from combustion of fossil fuels and intensive farming, increasing nitrate concentrations in the soil.

Harebell, *Campanula rotundifolia,* is a wild flower species that is found in many areas of the UK. It is adapted to low nitrate levels.

Students carried out an investigation to compare the population densities of *Campanula rotundifolia* growing in two natural grassland areas with different nitrate levels.

0 9 . 1 Suggest how students would select suitable sites to ensure valid results.

[2 marks]

_____

_____

_____

_____

0 9 . 2 Describe a method that students would use to collect the data at these sites.

[3 marks]

_____

_____

_____

_____

_____

_____

0 9 . 3 Suggest an appropriate statistical test that the students could use to analyse their results.

Justify your choice.

[1 mark]

Appropriate statistical test _____

_____

Justification _____

_____

Turn over ►

Do not write outside the box

0 9 . 4 Applications of nitrate fertilisers can cause leaching into nearby water.

Outline **one** method that can be used to test for nitrates in water.

[2 marks]

0 9 . 5 Explain how **one** farming activity, other than the application of fertilisers, can affect the nitrate concentration in soil.

[2 marks]

10

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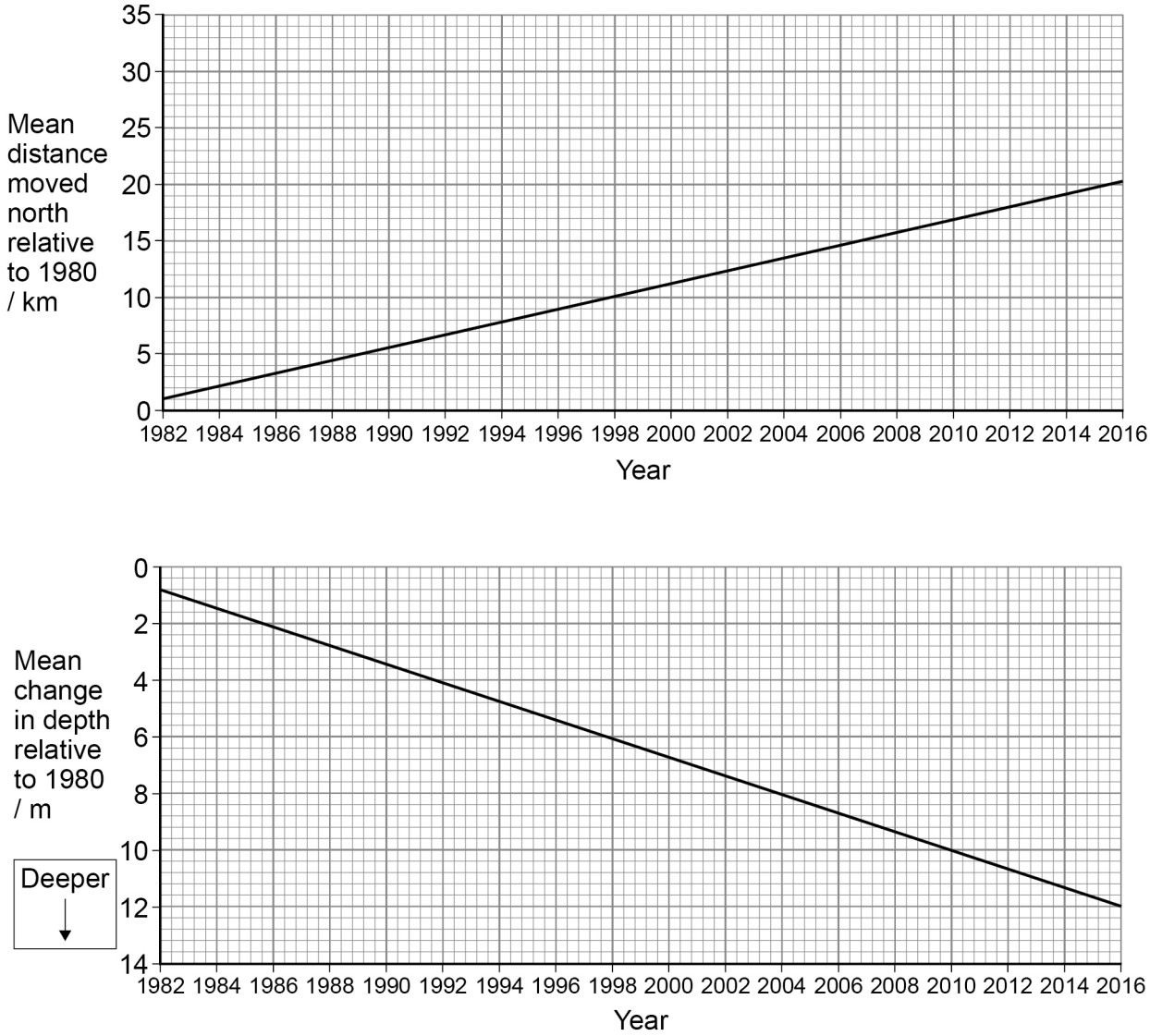
1 0 Summer water temperatures in the Bering Sea in the western Arctic were nearly 2 °C warmer in 2003 than 1995. Many animal species in the Bering Sea are being replaced by species from warmer conditions to the south.

Figure 5 shows the mean distance moved north and the mean change in depth relative to 1980 of 105 marine fish and crustacean species between 1982 and 2016.

Figure 5



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1 0 . 1 Suggest why temperature change has altered the distribution of species as shown in **Figure 5**.

[2 marks]

_____

_____

_____

_____

1 0 . 2 The data shown in **Figure 5** were collected at the same time each year.

Suggest **two** reasons why this increases validity of the data.

[2 marks]

1 _____

_____

2 _____

_____

Question 10 continues on the next page

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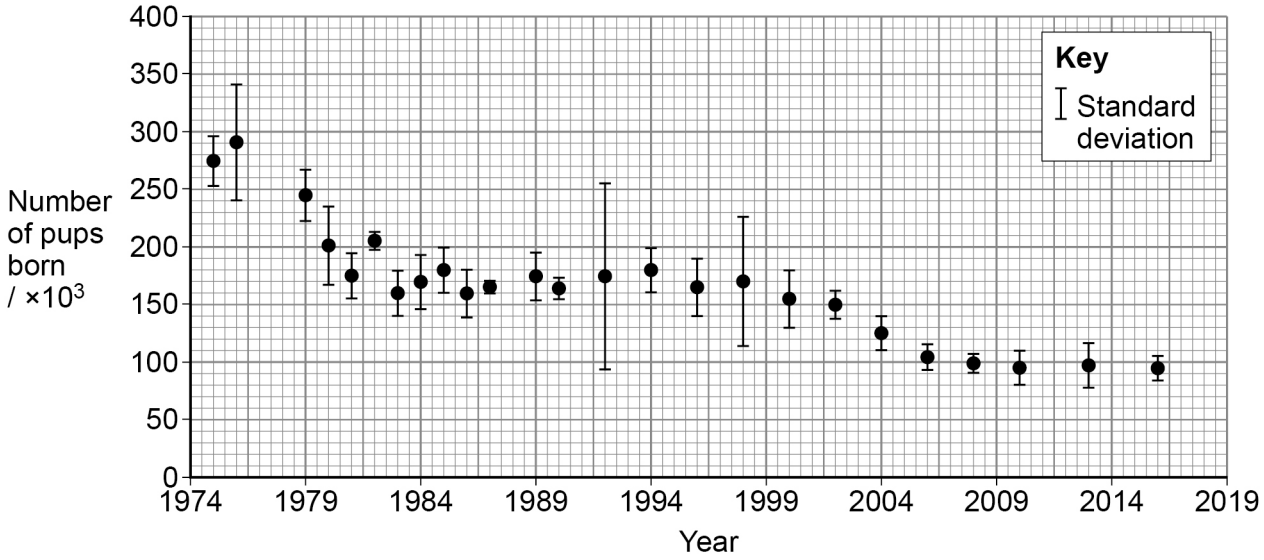
Figure 6 shows estimates of the number of Northern fur seal, *Callorhinus ursinus,* pups born on St. Paul Island in the Bering Sea between 1975 and 2016.

Figure 6



1 0 . 3 Compare the data during the years 1989 to 2000. State which of these years provided the most reliable estimate. Give a reason for your answer.

[2 marks]

Year _____

_____

Reason _____

_____

1 0 . 4 One of the effects of global climate change is an increase in sea level.

Explain why rising sea levels may influence the distribution and survival of species.

[9 marks]

_____

_____

_____

_____

_____

_____

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Extra space

15

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Write an essay on **one** of the following topics.

1 1 . 1 Discuss the extent to which control methods reduce the environmental impacts of pollutants.

[25 marks]

OR

1 1 . 2 Discuss the extent to which methods of energy conservation reduce environmental impacts.

[25 marks]

Shade the lozenge below to indicate which optional question you have answered.

Question **1 1 . 1** ⬭ Question **1 1 . 2** ⬭

CORRECT METHOD ⬬ WRONG METHODS

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Extra space

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25

END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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